CLAIMS

What is claimed is:

1. A heat exchanger comprising:
   a. an interface layer in contact with the heat source and configured to pass fluid therethrough to cool the heat source; and
   b. a manifold layer coupled to the interface layer, the manifold layer further comprising a first set of individualized fluid paths for channeling fluid to the interface layer, the individual fluid paths in the first set positioned to minimize pressure drop within the heat exchanger.

2. The heat exchanger according to claim 1 wherein the manifold layer further comprises a second set of individualized fluid paths for channeling fluid from the interface layer.

3. The heat exchanger according to claim 2 wherein the manifold layer further comprises a first port for providing fluid to the first set of individualized fluid paths and a second port for removing fluid channeled from the second set of individualized fluid paths.

4. The heat exchanger according to claim 1 wherein the first set of fluid paths are arranged to provide a minimized fluid path distance along the interface layer to cool a predetermined region of the heat source to a desired temperature.

5. The heat exchanger according to claim 3 wherein the first set and second set of fluid paths are arranged to provide a minimized fluid path distance between the first and second ports to cool a predetermined region of the heat source to a desired temperature.

6. The heat exchanger according to claim 1 wherein the fluid is in single phase flow conditions.

7. The heat exchanger according to claim 1 wherein at least a portion of the fluid is in two phase flow conditions.

8. The heat exchanger according to claim 1 wherein at least a portion of the fluid undergoes a transition between single and two phase flow conditions in the heat exchanger.

9. The heat exchanger according to claim 2 wherein the manifold layer further comprises a circulation level having the first and second fluid paths extending therethrough, the circulation level coupled to the interface layer and configured to separably channel fluid to and from the interface layer via the first and second set of fluid paths.

10. The heat exchanger according to claim 9 wherein each of the fluid paths in the first set include a cylindrical protrusion in communication therewith, each cylindrical protrusion extending from the circulation level at a predetermined height.

11. The heat exchanger according to claim 3 wherein the manifold layer further comprises
   a. a first level configured to channel fluid between the first port and the first set of fluid paths; and
   b. a second level coupled to the first level and configured to channel fluid between the second port and the second set of fluid paths wherein fluid channeled via the first level is kept separate from the fluid channeled via the second level in the manifold layer.

12. The heat exchanger according to claim 11 wherein the first level further comprises a first corridor in communication with the first port and the first set of fluid paths, wherein fluid in the first corridor flows directly to the first set of fluid paths.

13. The heat exchanger according to claim 11 wherein the second level further comprises a second corridor in communication with the second port and the second set of fluid paths wherein fluid in the second set flows directly to the second corridor.

14. The heat exchanger according to claim 2 wherein the first set of fluid paths are thermally insulated from the second set of fluid paths to prevent heat transfer therebetween.

15. The heat exchanger according to claim 2 wherein the first set and the second set of fluid paths are arranged in a uniform manner along at least one dimension.

16. The heat exchanger according to claim 2 wherein the first set and second set of fluid paths are arranged in a non-uniform manner along at least one dimension.

17. The heat exchanger according to claim 1 wherein each fluid paths in the first set is positioned a closest optimal distance to one another.

18. The heat exchanger according to claim 2 wherein the first set and second set of fluid paths are positioned to cool at least one interface hot spot region in the heat source.

19. The heat exchanger according to claim 2 wherein at least one of the first fluid paths flows via a plurality of first holes, wherein at least one first hole in the plurality has a first dimension substantially equivalent to a second dimension of at least one hole in the second set of fluid paths.

20. The heat exchanger according to claim 2 wherein at least one of the first fluid paths flows via a plurality of first holes, wherein at least one first hole in the plurality has a first dimension different than a second dimension of at least one second hole in the second set of fluid paths.

21. The heat exchanger according to claim 1 wherein the interface layer is made of a material having a thermal conductivity of at least 100 W/mk.

22. The heat exchanger according to claim 1 wherein the interface layer further comprises a plurality of pillars configured in a predetermined pattern along the interface layer.

23. The heat exchanger according to claim 22 wherein at least one of the plurality of pillars includes at least varying dimension along a predetermined direction.

24. The heat exchanger according to claim 22 wherein an appropriate number of pillars are disposed in a predetermined area along the interface layer.

25. The heat exchanger according to claim 1 wherein at least a portion of the interface layer has a roughened surface.

26. The heat exchanger according to claim 22 wherein the plurality of pillars include a coating thereupon, wherein the coating has an appropriate thermal conductivity of at least 10 W/m-K.

27. The heat exchanger according to claim 1 further comprising a porous microstructure disposed along the interface layer.

28. The heat exchanger according to claim 27 wherein the porous microstructure includes at least one pore having a varying dimension along a predetermined direction.

29. The heat exchanger according to claim 1 further comprising a plurality of microchannels disposed in a predetermined configuration along the interface layer.

30. The heat exchanger according to claim 1 wherein the interface layer is coupled to the heat source.

31. The heat exchanger according to claim 1 wherein the interface layer is integrally formed to the heat source.

32. The heat exchanger according to claim 1 wherein the heat source is an integrated circuit.

33. A heat exchanger configured to cool a heat source comprising:

a. an interface layer in contact with the heat source and configured to pass fluid therethrough; and

b. a manifold layer coupled to the interface layer, the manifold layer further comprising:

i. a first level having a plurality of substantially vertical inlet paths for delivering fluid to the interface layer, wherein the inlet paths are arranged an optimal fluid travel distance from one another other; and

ii. a second level having at least one outlet path for removing fluid from the interface layer.

34. The heat exchanger according to claim 33 wherein the first level further comprises at least one first port configured to channel fluid to the inlet paths.

35. The heat exchanger according to claim 34 wherein the second level further comprises at least one second port configured to channel fluid from the at least one outlet path, wherein fluid in the second level flows separately from the fluid in the first level.

36. The heat exchanger according to claim 35 wherein the second level further comprises a plurality of substantially vertical outlet paths for removing fluid from the interface layer, the plurality of inlet and outlet paths arranged an optimal fluid travel distance apart from each other.

37. The heat exchanger according to claim 36 wherein the manifold layer further comprises a circulation level coupled to the interface layer and having a plurality of first apertures extending vertically therethrough for channeling fluid along the inlet paths to the interface layer and a plurality of second apertures extending vertically therethrough for channeling fluid along the at least outlet path from the interface layer.

38. The heat exchanger according to claim 37 wherein the first level further comprises an inlet fluid corridor within for horizontally channeling fluid from the first port to the first apertures.

39. The heat exchanger according to claim 38 wherein the second level further comprises an outlet fluid corridor for horizontally channeling fluid from the second apertures to the second port.

40. The heat exchanger according to claim 37 wherein the first and second apertures are individually arranged in a uniform manner along at least one dimension.

41. The heat exchanger according to claim 37 wherein the first and second fluid apertures are individually arranged in a non-uniform manner along at least one dimension.

42. The heat exchanger according to claim 33 wherein the inlet paths and the at least one outlet paths are separately sealed from one another in the manifold layer.

43. The heat exchanger according to claim 33 wherein the interface layer is coupled to the heat source.

44. The heat exchanger according to claim 33 wherein the interface layer is integrally formed to the heat source.

45. The heat exchanger according to claim 33 wherein the heat source is an integrated circuit.

46. The heat exchanger according to claim 37 wherein the first and second apertures are arranged to cool at least one interface hot spot cooling region in the heat source.

47. The heat exchanger according to claim 37 wherein at least one of the first apertures has an inlet dimension substantially equivalent to an outlet dimension of at least one second apertures in the plurality.

48. The heat exchanger according to claim 37 wherein at least one of the first apertures has an inlet dimension different than an outlet dimension of at least one of the second apertures in the plurality.

49. The heat exchanger according to claim 33 wherein the interface layer is made of a material having a thermal conductivity of at least 100 W/mk.

50. The heat exchanger according to claim 33 wherein the interface layer further comprises a plurality of pillars disposed thereon in an appropriate pattern.

51. The heat exchanger according to claim 50 wherein at least one of the plurality of pillars includes at least varying dimension along a predetermined direction.

52. The heat exchanger according to claim 50 wherein an appropriate number of pillars are disposed in a predetermined area along the interface layer.

53. The heat exchanger according to claim 33 wherein at least a portion of the interface layer has a roughened surface.

54. The heat exchanger according to claim 50 wherein the plurality of pillars include a coating thereupon, wherein the coating has an appropriate thermal conductivity of at least 10 W/m-K.

55. The heat exchanger according to claim 33 further comprising a porous microstructure disposed along the interface layer.

56. The heat exchanger according to claim 55 wherein the porous microstructure includes at least one pore having a varying dimension along a predetermined direction.

57. The heat exchanger according to claim 55 wherein an average pore size in the porous microstructure is within the range and including 30 microns and 300 microns.

58. The heat exchanger according to claim 55 wherein at least one region of the porous microstructure has a porosity in the range and including 0.3 and 0.8.

59. The heat exchanger according to claim 33 wherein the interface layer further comprises a plurality of microchannels disposed thereon in an appropriate pattern.

60. The heat exchanger according to claim 37 further comprising a plurality of cylindrical protrusions extending an appropriate height from the circulation level, each protrusion in communication with the first apertures.

61. A manifold layer adapted to coupleable to an interface layer to form a microchannel heat exchanger comprising:

a. an inlet port for providing a first temperature fluid;

b. an inlet fluid path in communication with the inlet port, the inlet fluid path adapted for channeling first temperature fluid to the interface layer;

c. an outlet fluid path adapted for removing a second temperature fluid from the interface layer, wherein the first temperature fluid and the second temperature fluid are kept separate in the manifold layer; and

d. an outlet port in communication with the outlet fluid path, wherein the second temperature fluid exits the manifold layer via the outlet port.

62. The manifold layer according to claim 61 further comprising

a. a first layer having a fluid exit corridor in communication with the outlet corridor and the outlet fluid path; and

b. a second layer coupled to the first layer and having a fluid entry corridor in communication with the inlet port and the inlet fluid path.

63. The manifold layer according to claim 62 further comprising a third layer having a series of substantially vertical inlet passages for channeling the first temperature fluid and a series of substantially vertical outlet passages for channeling the second temperature fluid, each inlet passage in communication with the inlet flow path and each outlet passage in communication with the outlet flow path, wherein each inlet and outlet passage is arranged to minimize pressure drop therebetween.

64. The manifold layer according to claim 63 wherein the inlet and outlet passages are arranged in a uniform manner along at least one dimension.

65. The manifold layer according to claim 63 wherein the inlet and outlet passages are arranged in a non-uniform manner along at least one dimension of the third layer.

66. The manifold layer according to claim 63 wherein the inlet and outlet apertures are separately sealed from one another.

67. The manifold layer according to claim 63 wherein at least one of the inlet passages has an inlet dimension substantially equivalent to an outlet dimension of at least one outlet passage.

68. The manifold layer according to claim 63 wherein at least one of the inlet passages has an inlet dimension than an outlet dimension of at least one outlet passage.

69. A method of manufacturing a heat exchanger configured to cool a heat source, the method comprising the steps of:

a. forming an interface layer configurable to be in contact with the heat source to pass fluid therethrough;

b. forming a manifold layer to include at least one inlet fluid path and at least one outlet fluid path, the at least one inlet fluid path and the at least one outlet fluid path arranged to channel fluid flow an optimal minimum distance therebetween along the interface layer; and

c. coupling the manifold layer to the interface layer.

70. The method of manufacturing according to claim 69 further comprising the steps of:
   a. configuring at least one inlet fluid port to the at least one inlet fluid path wherein fluid enters the heat exchanger via the inlet fluid port; and
   b. configuring at least one fluid port to the at least one outlet fluid path, wherein fluid exits the heat exchanger via the outlet port.

71. The method of manufacturing according to claim 69 wherein the step of forming the manifold layer further comprises forming a circulation level having a plurality of inlet apertures extending vertically therethrough to the interface layer and configureable to channel inlet fluid through the at least one inlet fluid paths and a plurality of outlet apertures extending vertically therethrough to the interface layer and configureable to channel outlet fluid through the at least one outlet fluid paths.

72. The method of manufacturing according to claim 71 wherein the step of forming the manifold layer further comprises:
   a. forming an inlet level configureable to channel fluid from the inlet port to the inlet apertures via the inlet corridor; and
   b. coupling the inlet level to the circulation level, wherein the inlet apertures are sealably coupled with the inlet corridor.

73. The method of manufacturing according to claim 72 wherein the step of forming the manifold layer further comprises:
   a. forming an outlet level configureable to channel fluid from the outlet port to the outlet apertures via the outlet corridor; and
   b. coupling the outlet level to the circulation level, wherein the outlet apertures are sealably coupled with the outlet corridor.

74. The method of manufacturing according to claim 69 wherein the at least one inlet fluid path and the at least one outlet fluid path are positioned to cool at least one interface hot spot region in the heat source.

75. The method of manufacturing according to claim 69 further comprising the step of insulating the at least one fluid inlet paths and the at least one fluid outlet paths in the manifold layer to minimize heat transfer therebetween.

76. The method of manufacturing according to claim 69 wherein the interface layer is made of a material having a thermal conductivity of at least 100 W/m-K.

77. The method of manufacturing according to claim 69 further comprising the step of applying a thermally conductive coating to the interface layer.

78. The method of manufacturing according to claim 77 wherein the thermal conductive coating is applied to the interface layer by an electroplating process.

79. The method of manufacturing according to claim 69 further comprising forming a plurality of pillars in a predetermined pattern along the interface layer.

80. The method of manufacturing according to claim 79 wherein at least one of the plurality of pillars includes at least varying dimension along a predetermined direction.

81. The method of manufacturing according to claim 69 further comprising configuring at least a portion of the interface layer to have a roughened surface.

82. The method of manufacturing according to claim 69 further comprising configuring a micro-porous structure disposed on the interface layer.

83. The method of manufacturing according to claim 69 further comprising forming a plurality of microchannels onto the interface layer.

84. The method of manufacturing according to claim 79 further comprising the step of applying a thermally conductive coating to the plurality of pillars.

85. The method of manufacturing according to claim 79 wherein the plurality of pillars are formed by an electroforming process.

86. The method of manufacturing according to claim 79 wherein the plurality of pillars are formed by an etching process.

87. The method of manufacturing according to claim 86 wherein the etching process includes a wet etching process.

88. The method of manufacturing according to claim 87 wherein the etching process includes a plasma etching process.

89. The method of manufacturing according to claim 87 wherein the etching process includes a photochemical etching process.

90. The method of manufacturing according to claim 87 wherein the etching process includes a chemical etching process.

91. The method of manufacturing according to claim 87 wherein the etching process includes a laser assisted chemical etching process.

92. The method of manufacturing according to claim 69 wherein the interface layer is formed by a laser assisted chemical etching process.

93. The method of manufacturing according to claim 79 wherein the electroforming process is performed in combination with a hot embossing technique.

94. The method of manufacturing according to claim 79 wherein the electroforming process further comprises utilizing a soft lithography technique.

95. The method of manufacturing according to claim 69 wherein the manifold layer is formed by a laser drilling process.

96. The method of manufacturing according to claim 69 wherein the manifold layer is formed by a soft lithography process.

97. The method of manufacturing according to claim 69 wherein the manifold layer is formed by an injection molding process.

98. The method of manufacturing according to claim 69 wherein the manifold layer is formed by an machining process.

99. The method of manufacturing according to claim 69 wherein the manifold layer is formed by an EDM process.

100. The method of manufacturing according to claim 69 wherein the manifold layer is formed by a stamping process.

101. The method of manufacturing according to claim 69 wherein the manifold layer is formed by a MIM process.

102. The method of manufacturing according to claim 69 wherein the manifold layer is formed by cross cutting process.

103. The method of manufacturing according to claim 69 wherein the manifold layer is formed by a sawing process.

104. An electronic device which produces heat comprising:

a. an integrated circuit;

b. an interface layer for cooling heat produced by the electronic device, the interface layer integrally formed with the integrated circuit and configured to pass fluid therethrough; and

c. a manifold layer for circulating fluid with the interface layer, the manifold layer having at least one inlet fluid path for delivering fluid to the interface layer and at least one outlet fluid path for removing fluid from the interface layer, the at least one inlet fluid path and the at least one outlet fluid path arranged to provide an optimal minimum fluid travel distance apart from each other.

105. A closed loop system for cooling at least one integrated circuit comprising:

a. at least one heat exchanger for absorbing heat generated by the integrated circuit, the heat exchanger further comprising:

i. an interface layer in contact with the integrated circuit and configured to pass fluid therethrough; and

ii. a manifold layer coupled to the interface layer, the manifold layer having at least one inlet fluid path for delivering fluid to the interface layer and at least one outlet fluid path for removing fluid from the interface layer, the at least inlet fluid path and the at least one outlet fluid path arranged to provide an optimal minimum fluid travel distance apart from each other;

b. at least one pump for circulating fluid throughout the loop, the pump coupled to the at least one heat exchanger; and

c. at least one heat rejector coupled to the pump and the heat exchanger, the heat rejector for cooling heated liquid output from the heat exchanger.